Revue suisse de Zoologie, 103 (4): 795-800; décembre 1996

Synusial structure of heathlands at the subalpine/alpine ecocline in Valais (Switzerland)[1, 2]

André SCHLÜSSEL* & Jean-Paul THEURILLAT**
*Conservatoire Botanique Genève, Case postale 60, CH-1292 Chambésy.
**Fondation J.-M. Aubert, CH-1938 Champex & Conservatoire Botanique Genève, Case postale 60, CH-1292 Chambésy.

Synusial structure of heathlands at the subalpine/alpine ecocline in Valais (Switzerland). - In order to assess the impact of predicted climate changes in the next future, the floristic and synusial structure of heathlands were studied along two altitudinal transects at the subalpine and alpine levels in the Alps of the Valais. The first, south-east oriented transect is dominated with thermophilous, low heaths of *Arctostaphylos uva-ursi* (L.) Sprengel. The second, east oriented transect is dominated with mesophilous, taller heaths with *Rhododendron ferrugineum* L., *Vaccinium myrtillus* L., *V. uliginosum* subsp. *microphyllum* (Lange) Tolm. Both ecosystems show a thermal inertia but they will not react in the same way to climate change because the thermophilous heaths are mainly driven by temperature and the mesophilous heaths by snow cover.

Key-words: Alps - Climate change - Heath - Plant community - Subalpine - Alpine - Synusiae.

INTRODUCTION

In the near future, global climatological models predict an increase of mean global temperatures of 1.5-4.5 K with a doubling of the CO_2 concentration in the atmosphere (Houghton *& al.*, 1990, 1992). In order to assess the impact of this predicted climate change on the vegetation at the subalpine/alpine ecocline, the floristic and synusial structure of heathlands were studied along two altitudinal transects on siliceous rocks in the Alps of the Valais.

The first transect, where thermophilous, low heaths of *Arctostaphylos uva-ursi* (L.) Sprengel and *Calluna vulgaris* (L.) Hull are predominant, is located in the Val d'Arpette (Orsières) on a steep, rocky, south to south-east oriented slope, ranging from 1720 to 2814 m asl. The steep slopes of this site prevent any accumulation of large

---

[1] The present study is part of the project "Reaction of the vegetation to climate change in the subalpine/alpine ecocline" of the Priority Programme Environment of the Swiss National Science Foundation (Grant 5001-35341).

[2] Main lecture presented at Zoologia and Botanica 96.

quantities of snow, and the southern aspect induces a rapid snowmelt in early spring, particularly when spring snow precipitation has been low. According to our observations, the difference in the date of snowmelt from plots at the bottom of the transect and those at the limit of the upper heath communities (around 2500 m asl.) does not exceed one week.

The second transect, dominated with mesophilous, taller heaths with *Rhododendron ferrugineum* L., *Vaccinium myrtillus* L., *V. uliginosum* subsp. *microphyllum* (Lange) Tolm., and *Empetrum nigrum* subsp. *hermaphroditum* (Hagerup) Böcher, is located in the Aletsch region (Naters) on a more gentle, east oriented slope, ranging from 1900 to 2855 m asl. Contrary to the Val d'Arpette, there is an important snow cover in Belalp. Therefore, there is a difference of about three to four weeks for the date of snowmelt in the spring between the bottom of the transect and the top of the heaths at 2400-2500 m asl.

METHOD

According to the Braun-Blanquet method (Braun-Blanquet, 1932, Westhoff & Van Der Maarel, 1980), 77 phytosociological relevés (vegetation samples) (44 at the Val d'Arpette and 33 at Belalp) were carried out. Within the same plots, 539 synusial relevés were conducted (310 at the Val d'Arpette and 229 at Belalp). The synusiae were defined according to four main parameters: biological types, stratification, horizontal distribution, and seasonal replacement of the species. In this respect, synusiae group together plants having more or less the same stategy in their development, and in their ecological requirements. They represent ecological and organisational compartments of the community (Barkman, 1980; Walter, 1984, 1985).

The Braun-Blanquet relevés of heaths were classified into 17 plant communities, and the synusial relevés into 84 types of synusiae. Classification was performed with the help of the package for multivariate analyses MULVA 5 (Wildi, 1991, 1994).

RESULTS

Figure 1 shows the distribution of the different types of synusiae according to elevation at the Val d'Arpette. The synusiae appear to behave as two different systems, a lower subalpine and an upper subalpine system respectively. These two systems intergrade into each other gradually, but there is a clear discontinuity between 2000 and 2100 m where the lower subalpine synusiae disappear and most of the upper subalpine synusiae appear. This break appears to be related to a change of the slope at the tree line, the slope being less steep above.

Figure 2 shows the results for the Belalp site. Here, the synusial structure presents a great altitudinal uniformity amongst four synusiae, including the two most important ones. However, there is a regular, stepwise change in the composition of other synusiae with elevation.

DISCUSSION

In considerations of alpine climate, temperature and snow cover are the two main factors to be considered in high mountains at mid-latitudes, where temperature decreases regularly with elevation (0.55 K/100 m) (e.g. OZENDA, 1985). Snow cover is important in protecting plants against frost (e.g. LARCHER, 1994), and both temperature and snow cover determine the length of the vegetation growth period (e.g. ELLENBERG, 1986, 1988).

The early disappearance of snow in the spring on the southern slopes in the Val d'Arpette determines a relatively long vegetation growth period but, as a consequence, vegetation is poorly protected against late frost. Therefore, most dominant species of the prevalent synusiae are thermophilous but frost resistant species, such as *Arctostaphylos uva-ursi* (L.) Sprengel, *Juniperus communis* subsp. *alpina* (Suter) Celak, *Calluna vulgaris* (L.) Hull and *Festuca scabriculmis* subsp. *luedii* Mgf. - Dbg. Moreover, the structure of this vegetation forms a real "slipping plane" which helps snow slipping and snow creeping. Under climatic conditions which manifest only an increase in temperature, the lower subalpine synusiae will probably slowly invade higher elevations and push upwards, or even eliminate some of the upper subalpine synusiae, especially in the case of the highest predicted increase in temperature. This may happen with some inertia due to the delayed reaction of the plant species (e.g. persistance, dispersal), extreme climatic events, and the influence of the relief, in particular the slope between 2000 and 2100 m asl (THEURILLAT *& al.*, in print). These predicted changes may not be very dramatic because generally speaking, the heaths are floristically relatively homogeneous, in particular in the dominant synusiae, despite their important altitudinal range. Indeed, often the same species shifts from one synusiae to another, from the bottom to the top of the transect. For example, *Arctostaphylos uva-ursi* is dominant in the lower subalpine *Arctostaphylos/Vaccinium myrtillus* synusia, and it is also dominant in the upper subalpine *Arctostaphylos/Vaccinium uliginosum* synusia, in which *Vaccinium myrtillus* is still present. Thus, in the Val d'Arpette, temperature appears to be the main factor determining the composition and the structure of heaths, whereas snow appears to be of secondary importance in this respect, and a reduction in the snow cover may probably not greatly affect the heath formation, because of its frost resistance.

In contrast, the heath structure at Belalp seems to be mainly determined by the quantity of snow cover, with mesophilous, late frost sensitive species, such as *Rhododendron ferrugineum* L., *Empetrum nigrum* subsp. *hermaphroditum* (Hagerup) Böcher, and *Vaccinium myrtillus* L., but also a gradual stepwise replacement of some synusiae by others. The even distribution of the dominant synusiae independent of elevation shows that an increase in temperature alone will not modify these synusiae. However, with a longer vegetation growth period resulting from temperature increase, these synusiae will be able to slowly invade the alpine meadows. However, if there is a concominent decrease in winter precipitation, in particular of snow, the reduced snow cover which will result may no longer provide adequate protection to the sensitive, structurally predominant species. These species could thus be severely

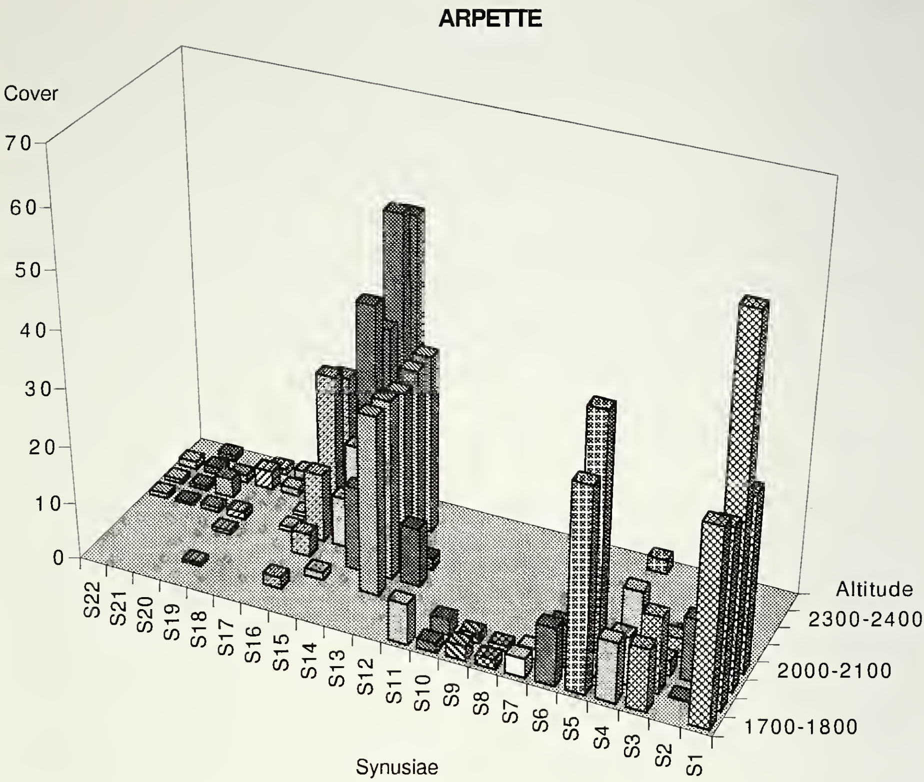

FIG. 1

Cover of the main heath synusiae (S1-S22) relative to elevation (expressed in altitudinal sections of 100 m) at the Val d'Arpette. Main synusiae: S1 = synusia of *Arctostaphylos uva-ursi* and *Vaccinium myrtillus*; S5 = synusia of *Vaccinium myrtillus* and *V. vitis-idaea*; S13 = synusia of *Arctostaphylos uva-ursi* and *Vaccinium uliginosum* subsp. *microphyllum*; S14 = synusia of *Vaccinium myrtillus* and *V. uliginosum* subsp. *microphyllum*; S16 = synusia of *Festuca scabriculmis* subsp. *luedii* and *Carex sempervirens.*

affected by such a situation, especially at lower elevations, and this could lead to a dramatic change in the species composition.

CONCLUSION

The natural climatic gradient which occurs in mountains appears to be an ideal tool to investigate the effects of climate change on the vegetation in high mountains. If the synusial gradient observed with altitude is truly correlated with a climatic gradient, the synusial structure of the vegetation provides the possibility for the assessment of the impact of climatic changes. In this respect, the synusiae appear to be more finely tuned than the whole plant communities.

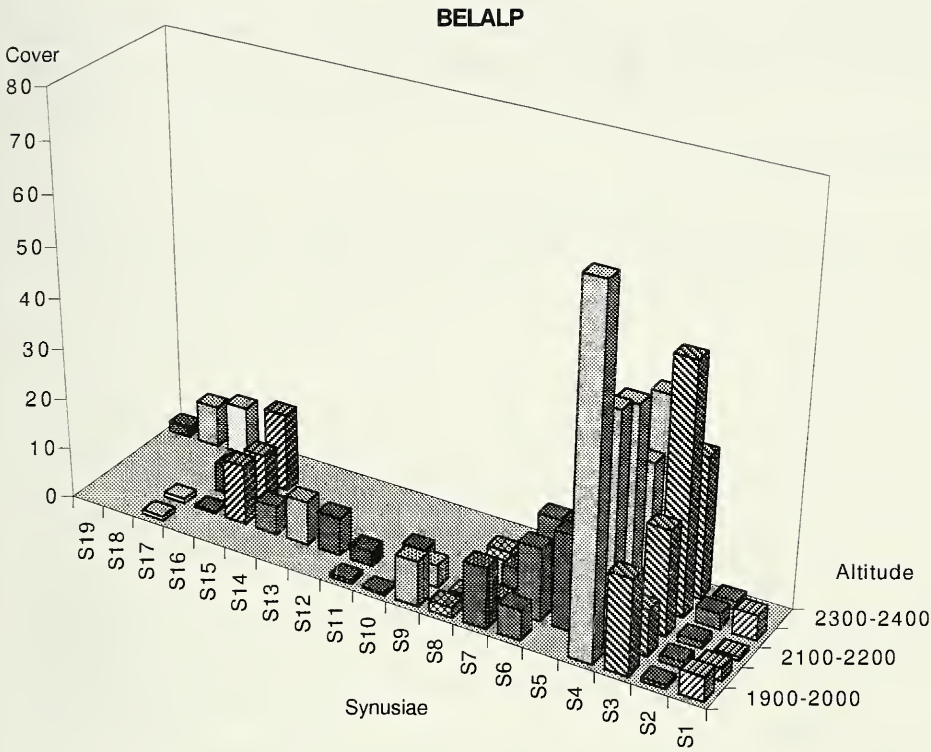

Fig. 2

Cover of the main heath synusiae (S1-S19) relative to elevation (expressed in altitudinal sections of 100 m) at Belalp. Main synusia: S1 = tall chamaephyte synusia of *Rhododendron ferrugineum*; S2 = synusia of *Homogyne alpina* and *Geum montanum*; S3 = synusia of *Loizeleuria procumbens* and *Vaccinium uliginosum* subsp. *microphyllum*; S4 = synusia of *Empetrum nigrum* subsp. *hermaphroditum* and *V. uliginosum* subsp. *microphyllum*.

The structure of the subalpine heaths is determined mainly by a few dominant clonal ericaceous species (including the *Empetraceae*), which are almost independent of community types once a preliminary distinction of thermophilous, mesophilous and cryophilous ecosystems is made. Thus, there are two dominant synusiae, independent of elevation in the mesophilous ecosytem of Belalp, and two systems of three to four dominant synusiae related to altitude in the thermophilous ecosystem of the Val d'Arpette. Both ecosystems show a thermal inertia which, at most, is equivalent to their altitudinal amplitude (ca. 600 m), that is ca. 3.3 K at their highest elevations. However, these two ecosystems will not react in the same way to climate change because the thermophilous heaths are mainly driven by temperature and the mesophilous heaths by snow cover. Therefore, a climate change involving a reduction of snow cover may act more on mesophilous heaths, because of their sensitivity to frost, than on thermophilous ones.

ACKNOWLEDGEMENTS

We are very grateful to Loraine Kohorn, Duke University, Durham, NC, for the linguistic revision, and to Prof. R. Spichiger for the facilities provided at the Conservatoire et Jardin botaniques of the city of Geneva.

REFERENCES

Barkman, J. J. (1980). Synusial approaches to classification. In: R. H. Whittaker (ed.) *Classification of plant communities*, ed. 2. Junk, Den Haag: 111-165.

Braun-Blanquet, J. (1932). *Plant sociology*. McGraw Hill, London, 439 pp.

Ellenberg, H. (1986). *Vegetation Mitteleuropas mit den Alpen in ökologischer Sicht*, ed. 3. Ulmer, Stuttgart, 989 pp.

Ellenberg, H. (1988). *Vegetation ecology of Central Europe*, ed. 4. Cambridge University Press, Cambridge, 732 pp.

Houghton, J. T., G. J. Jenkins, & J. J. Ephraums (eds.) 1990. *Climate change - the IPCC scientific assessment*. Cambridge University Press, Cambridge, 365 pp.

Houghton, J. T., B. A. Callander & S. K. Varney (eds.) *Climate change 1992. The supplementary report to the IPCC scientific assessment*. Cambridge University Press, Cambridge, 200 pp.

Larcher, W. (1994). *Ökophysiologie der Pflanzen*. Ulmer, Stuttgart, 394 pp.

Ozenda, P. (1985). *La végétation de la chaîne alpine dans l'espace montagnard européen*. Masson, Paris, 344 pp. + 1 carte.

Theurillat, J.-P., F. Felber, P. Geissler, J.-M. Gobat, M. Fierz, A. Fischlin, P. Küpfer, A. Schlüssel, C. Velluti, G.-F. Zhao & J. Williams (in print). Sensitivity of plant and soil ecosystems of the Alps to climate change. *In:* Cebon, P., U. Dahinden, H. Davies, D. Imboden & C. Jäger (eds.) *A view from the Alps: Regional perspectives on climate change*. MIT Press, Boston.

Walter, H. (1984). *Vegetation und Klimazonen*. Ulmer, Stuttgart, 382 pp. + 1 carte.

Walter, H. (1985). *Vegetation of the earth and ecological systems of geobiosphere*, ed. 3. Springer, Heidelberg, 318 pp.

Westhoff, V. & E. Van Der Maarel (1980). The Braun-Blanquet approach. *In:* R. H. Whittaker (ed.) *Classification of plant communities*, ed. 2. Junk, Den Haag: 287-399.

Wildi, O. (1991). Mulva-4, a processing environment for vegetation analysis. *In:* Feoli, E. & L. Orloci (eds.) *Computer assisted vegetation analysis*. Handbook Veg. Sci. 11, Kluver, Dordrecht: 407-428.

Wildi, O. (1994). *Datenanalyse mit Mulva*-5. Arbeitskopie, WSL, Birmensdorf, 73 pp.